

AMENDMENTS TO THE SPECIFICATION:

Please amend page 1, paragraph 2, to read as follows:

FIELD OF THE INVENTION

_____The present invention relates generally to [a drive system and in particular, but not exclusively, to a drive system for a bicycle. The drive system is also applicable to other] human-powered vehicles and mechanisms[. The invention also relates] and, more particularly, to a [bicycle having a] drive system for bicycles or the like.

Please amend page 1, paragraph 3, to read as follows

BACKGROUND OF THE INVENTION

_____ [The d]Drive systems [used by conventional] for bicycles [consists of] typically comprise a pair of rotating pedal cranks connected [by a chain and sprockets] to the rear wheel of the bicycle by a chain and sprockets. [This] Although these systems have been found useful, they also ha[s]ve [certain] inherent disadvantages. In particular, the tangential force exerted on the pedals by the cyclist [is able to exert on the pedals] varies considerably [according to] depending upon the relative position[s] of the pedal cranks [and is], the force generally being at a maximum only when the pedal cranks are approximately horizontal. This not only limits [the] efficiency [and/or], but also the maximum power output of the cyclist.

Please amend page 1, paragraph 4, to read as follows:

_____[DE 4404831 A describes] Another approach utilizes a drive system [including] having a drive link [that is] coupled by bearings to a crank and a tie rod. Drive [is] forces are then transmitted by a cyclist from the drive link, through the crank, to the wheels of a bicycle. A system of this general description is provided, for example, in DE 4404831 A. A further conventional drive mechanism for bicycles has pedals attached to racks mounted for reciprocating movement. Such a mechanism is disclosed, for instance, in WO 96/22911.

Please amend page 1, paragraph 5, to read as follows:

[WO 96/22911 describes a drive mechanism for a bicycle, in which the pedals are attached to racks mounted for reciprocating movement.]

Please amend page 1, paragraph 6, to read as follows:

[SUMMARY OF THE INVENTION]

- - OBJECTS AND SUMMARY OF THE INVENTION - -

_____It is, therefore, an object of the present invention to provide a drive system that [mitigates the aforementioned disadvantage] not only improves efficiency, but also the maximum power output of a cyclist. [A further object of the present invention is to

provide a bicycle having a drive system that enables the cyclist to provide a greater power output and/or to cycle more efficiently.]

Another object of the present invention is to provide a bicycle with a drive system that enables a cyclist to provide greater power output and/or cycle more efficiently.

Please amend page 1, paragraph 7, to read as follows:

____ According to one aspect of the present invention, [there is provided] a drive system is provided suitable for use in a bicycle[, said drive]. The system includ[ing]es a manually-operable [means] member and a drive train connected to the [manually-operable means] member for transferring drive from the [manually-operable means] member to at least one of the bicycle wheels[, wherein the]. The manually-operable [means] member is preferably mounted for substantially rectilinear reciprocating movement on a lever system [that]. The lever system includes a first lever having a first end connected to a first pivot, and a second end [that is] rotatable about the first pivot[, a]. A second lever is also provided, the second lever having a first end [that is] pivotably connected to the second end of the first lever and a second end to which the manually-operable [means] member is attached. In addition, [and] the lever system has a tie rod [having] with a first end [that is] pivotably connected to a second pivot and a second end [that is] pivotably connected to the second lever between the first and second ends thereof[; characterised in that the]. The first lever is desirably constructed and arranged for limited reciprocating rotation of the second end about the first pivot.

Please insert the following new paragraphs after paragraph 7 on page 1:

- - In accordance with another aspect of the present invention, a bicycle is provided having a drive system that includes a manually-operable member and a drive train connected to the member for transferring drive from the member to at least one of the bicycle wheels. The manually-operable member is preferably mounted for substantially rectilinear reciprocating movement on a lever system. The lever system includes a first lever having a first end connected to a first pivot, and a second end rotatable about the first pivot. A second lever is also provided, the second lever having a first end pivotably connected to the second end of the first lever and a second end to which the manually-operable member is attached. In addition, the lever system has a tie rod with a first end pivotably connected to a second pivot and a second end pivotably connected to the second lever between the first and second ends thereof. The first lever is desirably constructed and arranged for limited reciprocating rotation of the second end about the first pivot.

According to a further aspect of the present invention, a drive system is provided suitable for use in a bicycle. The system includes a manually-operable member and a drive train connected to the member for transferring drive from the member to at least one of the bicycle wheels. The manually-operable member is preferably mounted for substantially rectilinear reciprocating movement on a lever system. The lever system includes a first lever having a first end connected to a first pivot, and a second end rotatable about the first pivot. A second lever is also provided, the second lever having a first end pivotably connected to the second end of the first lever and a second end to

which the manually-operable member is attached. In addition, the lever system has a tie rod with a first end pivotably connected to a second pivot and a second end pivotably connected to the second lever between the first and second ends thereof. The first lever is preferably constructed and arranged for limited reciprocating rotation of the second end about the first pivot. The drive system further includes a hydraulic drive pump connected through a hydraulic circuit to a hydraulic motor that, in use, is arranged to drive at least one bicycle wheel, the hydraulic motor being arranged to provide a gearing effect.

In accordance with yet another aspect of the present invention, a bicycle is provided having a drive system substantially as described above. - -

Please amend page 2, paragraph 1, to read as follows:

[Although the drive system is suitable for use in a bicycle, it may also be used for driving other vehicles or mechanisms. It is not intended that the present invention is limited to drive systems for bicycles. The lever system produces the substantially rectilinear reciprocating movement of the manually-operable means, and is very efficient in operation.]

Please amend page 2, paragraph 2, to read as follows:

[The manually-operable means is preferably a pedal or a pair of pedals, although it may alternatively be a handle. Mounting the manually-operable means for substan-

tially rectilinear reciprocating movement allows a very efficient input of energy into the drive system from the user, avoiding the inefficiencies of traditional rotating crank systems. A bicycle equipped with the drive system can therefore be ridden more quickly and/or with less effort.]

Please amend page 2, paragraph 3, to read as follows:

[Advantageously, the drive system includes two lever systems that are interconnected for opposed reciprocating movement, each lever system including a manually-operable means. This allows both feet, or both hands, to be used to drive the system with alternating strokes.]

Please amend page 2, paragraph 4, to read as follows:

[The drive system may include a hydraulic drive pump that is connected to a third pivot and to the first lever between the first and second ends thereof, for actuation by pivoting movement of the first lever. The system may also include an adjuster device for adjusting the position of the third pivot relative to the first pivot, to adjust the stroke length of the cylinder. Advantageously, the adjuster device is a hydraulic adjuster. The hydraulic drive pump may be connected through a hydraulic circuit to a hydraulic motor.]

Please amend page 2, paragraph 5, to read as follows:

[The use of a hydraulic drive train allows drive to be transferred efficiently to the wheels, while adjusting stroke length of the hydraulic pump provides a simple method of adjusting the gearing effect of the drive system. If a hydraulic adjuster is used, an automatic or semiautomatic gearing system can be provided. While a hydraulic drive train is preferred, the drive train may alternatively be entirely mechanical.]

Please amend page 2, paragraph 6, to read as follows:

[In an alternative preferred form of the invention, the manually-operable means is attached to a shaft that is mounted for axial reciprocating movement. Advantageously, the system includes a pair of shafts mounted substantially parallel to one another for axial reciprocating movement, each said shaft having a manually-operable means attached thereto. The shafts are preferably interconnected for opposed reciprocating movement.]

Please amend from after paragraph 6 on page 2 to before the first full paragraph on page 3 to read as follows:

[This system also produces the substantially rectilinear reciprocating movement of the manually-operable means, and is very efficient in operation. The use of two parallel shafts that are interconnected for opposed reciprocating movement allows both feet, or both hands, to be used to drive the system with alternating strokes.]

Please amend page 3, first full paragraph, to read as follows:

[Advantageously, the shafts are drivingly connected to a sub-shaft that is mounted for axial reciprocating movement, and are preferably mounted substantially perpendicular to the sub-shaft. The sub-shaft may be connected to a hydraulic drive pump, which may be connected through a hydraulic circuit to a hydraulic motor. The use of a hydraulic drive train allows drive to be transferred efficiently to the wheels.]

Please amend page 3, second full paragraph, to read as follows:

[Advantageously, the hydraulic drive motor is a variable capacity motor, which allows the gearing effect of the drive system to be adjusted.]

Please amend page 3, third full paragraph, to read as follows:

[Advantageously, the drive system includes a plurality of hydraulic motors and means for connecting the motors into the hydraulic circuit individually, in series or in parallel, to adjust the gearing effect of the drive system.]

Please amend page 3, fourth full paragraph, to read as follows:

[According to another aspect of the present invention there is provided a bicycle having a drive system as described in the preceding paragraphs.]

Please amend page 3, fifth full paragraph, to read as follows:

[The bicycle may includes a hydraulic drive train including at least one hydraulic motor for driving the rear wheel, the front wheel or both wheels of the bicycle. The bicycle may include a plurality of hydraulic motors that can be connected into the hydraulic circuit individually, in series or in parallel to adjust the gearing effect of the drive system.]

Please add the following new paragraph after the fifth full paragraph on page 3:

- - The present invention will now be further described by reference to the following drawings which are not intended to limit the accompanying claims. - -

Please amend page 3, sixth full paragraph, to read as follows:

BRIEF DESCRIPTION OF THE DRAWINGS

_____[Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:]

Please amend page 3, seventh full paragraph, to read as follows:

_____[Fig.] FIG. 1 is a side view of a [first embodiment of the] drive system, according to one aspect of the present invention;

Please amend page 3, eighth full paragraph, to read as follows:

_____[Fig.] FIG. 2 is a side view of a bicycle having drive system as shown in [Fig.] FIG. 1;

Please amend page 3, ninth full paragraph, to read as follows:

_____[Fig.] FIG. 3 is a hydraulic circuit diagram of a hydraulic drive train for use with the drive system of FIG. 1;

Please amend page 3, tenth full paragraph, to read as follows:

_____[Fig.] FIG. 4 is an isometric view of a [second embodiment of the] drive system, according to another aspect of the present invention;

Please amend page 3, eleventh full paragraph, to read as follows:

_____[Fig.] FIG. 5 is a front view of the [second] drive system shown in FIG. 4;

Please amend page 3, twelfth full paragraph, to read as follows:

_____[Fig.] FIG. 6 is a side view of the [second] drive system[, and] illustrated in FIG. 4;

Please amend page 4, paragraph 1, to read as follows:

_____[Fig.] FIG. 7 is a [top] plan view of the [second] drive system[,] shown in FIG. 4;
and

Please amend page 4, paragraph 2, to read as follows:

_____[Fig.] FIG. 8 is a sectional view of a variable displacement motor forming part of
[the] a drive system, in accordance with the present invention.

Please add the following new paragraph after paragraph 2 on page 4:

- - The same numerals are used throughout the drawing figures to designate similar elements. Still other objects and advantages of the present invention will become apparent from the following description of the preferred embodiments. - -

Please amend page 4, paragraph 3, to read as follows:

DETAILED DESCRIPTION OF THE INVENTION

_____ [The invention relates to] Referring now to the drawings and, more particularly, to FIGS. 1-8, there is shown generally a specific, illustrative drive system for bicycles or other pedal driven mechanisms, in accordance with various aspects of the present invention. [The] According to one embodiment, the system includes a first arm 1 and a second arm 2, which are attached to [the] a bicycle frame 3 at their upper ends through first and second pivots 4, 5. A lever 6 is attached to the lower ends of the first and second arms through third and fourth pivots 7, 8, the third pivot 7 being located at one end of the lever [6] and the fourth pivot 8 being located between the ends of the lever, close to the third pivot [7]. A pedal 9 is attached to the free end of the lever [6], the arrangement being such that the pedal can move up and down substantially linearly, as indicated by the arrow label[1]ed “down”. [All t]These items may be duplicated in a generally symmetrical fashion for a second pedal.

. Please amend page 4, paragraph 4, to read as follows:

_____The first arm is attached to a drive train to turn the wheels or drive the mechanism. In a preferred arrangement of the design, the drive train [consists of] comprises a hydraulic drive cylinder 10, which is attached at its lower end to a pivot 11 on the first arm [1,] located between its ends. The hydraulic drive cylinder [10] is attached at its upper end to the bicycle frame [3] and a hydraulic adjuster 12. The hydraulic adjuster [12] is also attached to the frame [3] through a pivot 13 and may be actuated [to] for adjusting the position of the upper end of the drive cylinder relative to the frame. The hydraulic drive cylinder pumps oil around a hydraulic system. This

system, [which is] shown in [Fig.] FIG. 3, has an oil reservoir 15 [and], a regulation [system] and [a] control system 16, and one or more hydraulic motors 17.

Please amend from after paragraph 4 on page 4 to before the first full paragraph on page 5 to read as follows:

_____ When [a] pressure is exerted on the pedal 9, [the] lever 6 moves in the direction label[1]ed “down” and rotates [around] about pivot 7 [and].__[t]The resulting reaction through [the] second arm 2 forces [the] first arm 1 to rotate [around] about pivot 4, driving the hydraulic drive cylinder [10], which is arranged to pump oil around the hydraulic system. When [the] pedal 9 reaches the end of possible movement, it is so arranged to return to [the] its starting position at the opposite end of its range of movement. In so doing, [the] hydraulic drive cylinder 10 is refilled with fluid and the cycle [starts] begins again. The components are so arranged that movement of [the] hydraulic adjuster 12 has the effect of varying the amount of oil pumped around the system, thereby providing a continuously (i.e., steplessly) variable gearing system. The adjuster may be arranged in such a way that the fluid in the drive system operates the adjuster so as to provid[ing]e automatic adjustment of the gear ratios. Alternatively or concurrently, [B]both sides [may be] are connected to[gether] one another to ensure that the pedals move in opposite directions.

Please amend page 5, first full paragraph, to read as follows:

_____The hydraulic circuit may be arranged as shown in the diagram of FIG. 3, which is provided [included here] for clarity only. Fluid is drawn from [the] reservoir 15 through a one way valve 18 to the hydraulic drive cylinder [10] and pumped under pressure through another one way valve 19 to [the] regulation and control system 16 and [so], hence, through motors 17, as required, then returning to the reservoir. A relatively small amount of fluid [is] passe[d]s into a second control system 20 to actuate the hydraulic adjuster [12].

Please amend page 5, second full paragraph, to read as follows:

_____ [In a] Alternatively [arrangements], the hydraulic components [may be] are replaced by a gear, shaft or chain drive. In [these] such arrangements, provision [will be] is desirably made for relative movement of the pivots to provide a range of gear ratios.

Please amend page 5, third full paragraph, to read as follows:

_____The constituent parts are [so] arranged so that [the] movement of the pedal and, hence, output is in relation to the force that can be exerted on the pedal. There is no point in the cycle of the present invention that a full force cannot be output by the system. By aligning the direction of pedal movement with the input force, the system makes more efficient use of the work energy available.

Please amend page 5, fourth full paragraph, to read as follows:

_____[Various modifications of this drive system are possible. For example] Alternatively or concurrently, the drive cylinder may be connected to the second arm instead of the first arm; the lever to which the pedal is attached may be curved rather than straight; and the whole mechanism may be oriented differently, for example, when it is advantageous for the person operating the drive system to adopt [to] a reclined position.

Please amend page 5, fifth full paragraph, to read as follows:

_____Another alternative embodiment of the drive system is [shown] illustrated in [Figs.] FIGS. 4 to 7. In this [system] embodiment, [the] pedals 30 are attached to the lower ends of two parallel shafts 32[, which]. The shafts are mounted for axial movement in a housing 34 and are connected to a hydraulic drive piston 36 through a pair of transfer gears 38 and a piston shaft 40. The housing is shown in [Fig.] FIG. 6 but is omitted from the other figures for clarity.

Please amend page 5, sixth full paragraph, to read as follows:

_____Preferably, one face of [E]each pedal shaft 32 is provided [on one face] with a gear rack 42[:]. [i]In the embodiment shown in the drawings, the rack is [provided] on the rear face of the left-hand pedal shaft, and on the front face of the right-hand pedal shaft.

Please amend page 6, paragraph 1, to read as follows:

_____The transfer gears 38 are mounted in the housing 34 with their axes generally perpendicular to the axes of the pedal shafts 32. Each transfer gear includes a large radius gear 44 at its outer end, which engages the rack 42 on the associated pedal shaft, and a small radius gear 46 at its inner end, which engages an associated gear rack 48 on the upper side of [the] piston shaft 40.

Please amend page 6, paragraph 2, to read as follows:

_____The piston shaft [40] is mounted for axial movement in the housing [34] and is connected at one end to [the] hydraulic drive piston 36, which with a cylinder 50 forms a hydraulic drive pump 52. The hydraulic drive pump [52] is preferably connected through a hydraulic circuit to a drive motor. The drive motor may be a variable displacement motor[, to] for provid[e]ing a gearing effect.

Please amend page 6, paragraph 3, to read as follows:

_____To operate the drive system, [the] pedals 30 are pushed upwards and downwards by the rider, causing the pedal shafts [32] to reciprocate. This reciprocating movement is transferred to the piston shaft [40] by the transfer gears [38], which also increase the force and reduce the amplitude of the movement. This drives the hydraulic pump 52[,], which, in turn, drives the motor.

Please amend page 6, paragraph 4, to read as follows:

_____A suitable variable displacement motor or pump 54 is shown in [Fig.] FIG. 8. The motor [54] includes a rotor 56 that is hexagonal in cross-section and has six cylinders 57 around its circumference, in each of which there is mounted a piston 48. The rotor [56] is desirably mounted for rotation on a fixed, non-rotatable shaft 60 having a shaft axis 61. The six pistons 58 slidingly engage the inner hexagonal walls 62 of an outer housing 64[, which]. The outer housing is mounted on a mounting plate (not shown) for rotation about a housing 65 with the rotor [65], and is drivingly connected to one or both of the bicycle wheels.

Please amend page 6, paragraph 5, to read as follows:

_____Sealing walls 66 are provided on the shaft [60], which divide [the] annular gap 67 between the shaft and the rotor [56] into two halves. Oil is preferably fed to and drained from each half of this gap through an oil inlet opening 68 and an oil outlet opening 70 in the shaft [60]. Vents 72 in the rotor [56] extend between the gap [67] and [the] cylinders 57, allowing oil to drive the pistons [58].

Please amend from after paragraph 5 on page 6 to before the first full paragraph on page 7 to read as follows:

_____The shaft [60] is desirably mounted on an eccentric 73 having an axis of rotation 74[, which] that can be rotated so as to vary the separation between [the] shaft axis 61 and [the] housing axis 65. This allows the swept volume of [the] pump 54 to be varied, thereby adjusting the torque and [the] gearing ratio. Optionally, stops (not shown) are used to limit [R]rotation of the eccentric [may be limited by stops (not shown)].

Please insert the following new paragraph before the first full paragraph on page 7:

- - Although the present invention is shown and described as suitable for use in a bicycle, its application to driving other vehicles or mechanisms is understood, giving consideration to the purpose for which the present invention is intended. - -

Please amend page 7, first full paragraph, to read as follows:

_____In operation, oil is supplied under pressure through [the] inlet opening 68 into [the] gap 67 between the shaft [60] and the rotor [56], and passes through [the] vents 72 into the three cylinders 57 located on the inlet side of the gap [67], [so] driving [the] pistons 58 in th[os]e cylinders outward[s]ly. Generally [A]at the same time, oil is exhausted from the three cylinders on the outlet side of the gap [67] and escapes through [the] outlet opening 70. The relatively unbalanced force generated by the pistons creates a turning moment on the rotor, owing to the separation between [the] shaft axis 61 and

[the] housing axis 65. [The r]Rotor 56 and [the] outer housing 64, [therefore] in turn, rotate about the shaft [60], thereby driving the wheel or wheels of the bicycle.

Please amend page 7, second full paragraph, to read as follows:

_____.By rotating [the] eccentric 73, [the] separation between the shaft axis [61] and the housing axis [65] can be varied to adjust the torque and gearing ratio. Rotation of the eccentric [73] may be controlled manually or automatically (for example, mechanically or hydraulically) to provide a self-regulating drive system.

Please amend page 7, third full paragraph, to read as follows:

_____. [Various modifications of the drive system are possible. For example, in the According to still another alternative embodiment, as shown in the drawings, [the] transfer gears 38 are arranged to engage gear racks on opposite sides of [the] two pedal shafts 32, so that [the] pedals 30 move in opposite directions. Further in the [A]alternatively, the[y] the transfer gears can be arranged to engage gear racks on the same side of the two pedal shafts [32], and on opposite sides of [the] pump shaft 40, in order to produce the same effect. It is also possible to mount both transfer gears on a single shaft[, which has] having its axis situated diagonally [with respect] relative to the gear rack on the pump shaft.

Please insert the following new paragraphs after the third full paragraph on page 7:

- - Overall, the drive system, in accordance with the present invention, advantageously utilizes two lever systems interconnected for opposing reciprocating movement, where each lever system includes a manually-operable member. This allows both of the user's feet, or hands, to be used to drive the system with alternating strokes.

In addition, each lever system, according to the present invention, advantageously produces the substantially rectilinear reciprocating movement of the manually-operable member, and is very efficient in operation. In particular, mounting the member for substantially rectilinear reciprocating movement allows a very efficient input of energy into the drive system from the user, avoiding the inefficiencies of traditional rotating crank systems. A bicycle equipped with the drive system of the present invention can, therefore, be ridden more rapidly and/or with less effort. While it is preferred that the manually-operable member be a pedal or a pair of pedals, a handle may be used, alternatively or concurrently, within the spirit and scope of the present invention.

Optionally, the drive system also includes a hydraulic drive pump connected to a third pivot and to the first lever between the first and second ends thereof, for actuation by pivoting movement of the first lever. In addition, the system may include a device for adjusting the position of the third pivot relative to the first pivot, and thereby adjust the stroke length of the cylinder. Desirably, the adjuster device is a hydraulic adjuster.

A further benefit of the present invention is that the hydraulic drive pump may be connected, via a hydraulic circuit, to a hydraulic motor. By providing a hydraulic drive

train, the present invention allows drive to be transferred more efficiently to the wheels, while adjusting stroke length of the hydraulic pump provides a simple method for adjusting the gearing effect of the drive system. Notably, if a hydraulic adjuster is used, an automatic or semiautomatic gearing system can be provided. While a hydraulic drive train is preferred, it is understood that the drive train may, alternatively, be entirely mechanical.

Alternatively, the manually-operable member is attached to a shaft mounted for axial reciprocating movement. Beneficially, a pair of shafts mounted substantially parallel to one another provide for axial reciprocating movement, each shaft having a manually-operable member attached thereto and being desirably interconnected for opposing reciprocating movement. By using two parallel shafts interconnected for opposing reciprocating movement, both of the user's feet or hands may be used to drive the system with alternating strokes.

Advantageously, the shafts are drivingly connected to a sub-shaft mounted for axial reciprocating movement, preferably substantially perpendicularly to the sub-shaft. The sub-shaft may be connected to a hydraulic drive pump that is, in turn, connected via a hydraulic circuit to a hydraulic motor. Again, use of a hydraulic drive train allows drive to be transferred more efficiently to the wheels.

Further advantageous is that the hydraulic drive motor is a variable capacity motor that allows the gearing effect of the drive system to be adjusted. The drive system includes a plurality of hydraulic motors and a member for connecting the motors into the hydraulic circuit individually, in series or in parallel, to adjust the gearing effect of the drive system.